NATIONAL SEMICONDUCTOR

102035-A

NATIONAL SEMICONDUCTOR 4640

CONTENTS

F	Second function key. Accesses secondary functions when touched before a function key (page 7).
sin	Computes the sine of the angle in the display (page 28).
$\sin^{-1}$	Computes the arc sine of the number in the display (page 28).
cos	Computes the cosine of the angle in the display (page 28).
$\cos^{-1}$	Computes the arc cosine of the number in the display (page 28).
tan	Computes the tangent of the angle in the display (page 28).
$\tan^{-1}$	Computes the arc tangent of the number in the display (page 28).
DMS	Converts decimal degrees (or hours) in the display to degrees (or hours), minutes and seconds format (page 29).
D	Converts degrees (or hours), minutes and seconds in the display to decimal degrees (or hours) (page 29).
ln	Computes natural logarithm (base e, e = 2.71828...) of the number in the display (page 32).
e^x	Computes natural antilogarithm of the number in the display (raises e = 2.71828... to the power in the display) (page 33).
LOG	Computes common logarithm (base 10) of the number in the display (page 32).
10^x	Computes common antilogarithm of the number in the display (raises 10 to the power in the display) (page 32).
1/x	Computes reciprocal of the number in the display (divides 1 by the number in the display) (page 31).

y^x Raises number in the Y register to the power in the display (X register) (page 32).

$\sqrt{\ }$ Computes the square root of the number in the display (page 31).

x^2 Squares the number in the display (page 31).

→P Converts rectangular coordinates in X and Y registers to polar magnitude and angle (page 30).

→R Converts polar magnitude and angle stored in X and Y registers to rectangular coordinates (page 31).

M+ Automatically adds the number in the display to the number in memory register 1 (page 26).

x! Computes the factorial of the number in the display (page 40).

Σ+ Automatically accumulates summations of x, x^2 and n in memory registers 1, 2 and 3 (page 36).

Σ− Automatically subtracts summations of x, x^2 and n from memory registers 1, 2 and 3 (page 39).

% Computes percentages (x% of y) (page 34).

Δ% Computes amount and percent difference between numbers in the X and Y registers (page 35).

x⇄y Exchanges contents of X and Y registers (page 16).

ROLL Moves the contents of register X to register T, contents of register Y to register X, contents of register Z to register Y and contents of register T to register Z (page 15).

π Enters Pi (π) = 3.141592654 into the display (register X) (page 11).

MR Followed by number 1, 2 or 3, recalls number in memory register 1, 2 or 3 to display (page 24).

MS Followed by number key 1, 2 or 3, stores the number in the display in memory register 1, 2 or 3 (page 23). Followed by a + − × or ÷ key, then a number key 1, 2 or 3, performs direct register arithmetic on memory register 1, 2 or 3 (page 25).

SD Computes standard deviation using data accumulated in memory registers 1, 2 and 3 (page 38).

$\bar{x}$ Computes mean using data accumulated in memory registers 1 and 3 (page 38).

EEX Instructs calculator to accept next number entry as an exponent of 10 (page 10).

ENG Converts display format to engineering notation format (page 13).

CHS Changes the sign of the number in the display (page 10).

DS Followed by a number key, selects decimal place setting with automatic roundoff from 0-9 (page 12). Followed by ENG, converts display format to engineering format (page 13).

EN Copies number in display (register X) to register Y (page 18).

CF Cancels effect of F key (page 7).

→KG Converts number in display to kilograms (multiplies by .4535924) (page 42).

→CM Converts number in display to centimeters (multiplies by 2.54) (page 42).

→LIT Converts number in display to liters (multiplies by 3.785412) (page 42).

÷ Divides 'y' by 'x' (page 19).

→LB Converts number in display to pounds (divides by .4535924) (page 42).

→IN Converts number in display to inches (divides by 2.54) (page 42).

→GAL Converts number in display to gallons (divides by 3.785412) (page 42).

× Multiplies 'y' by 'x' (page 19).

DEG Sets angular mode to degrees (page 27).

GRAD Sets angular mode to grads (page 27).

RAD Sets angular mode to radians (page 27).

− Subtracts 'x' from 'y' (page 19).

°F Converts number in display to degrees fahrenheit (°F = 1.8°C+32) (page 43).

°C Converts number in display to degrees centigrade (°C = °F–32/1.8) (page 43).

C Clears display (register X) and drops stack down (page 11).

CA Clears entire stack and all three memory registers (page 11).

+ Adds 'x' to 'y' (page 19).

Your calculator is shipped fully assembled and ready to operate. Turn the calculator on with the switch on the left side of the machine. Your machine is automatically cleared and the display should now show 0. If it does not, check to see if the battery needs recharging by connecting the AC charger.

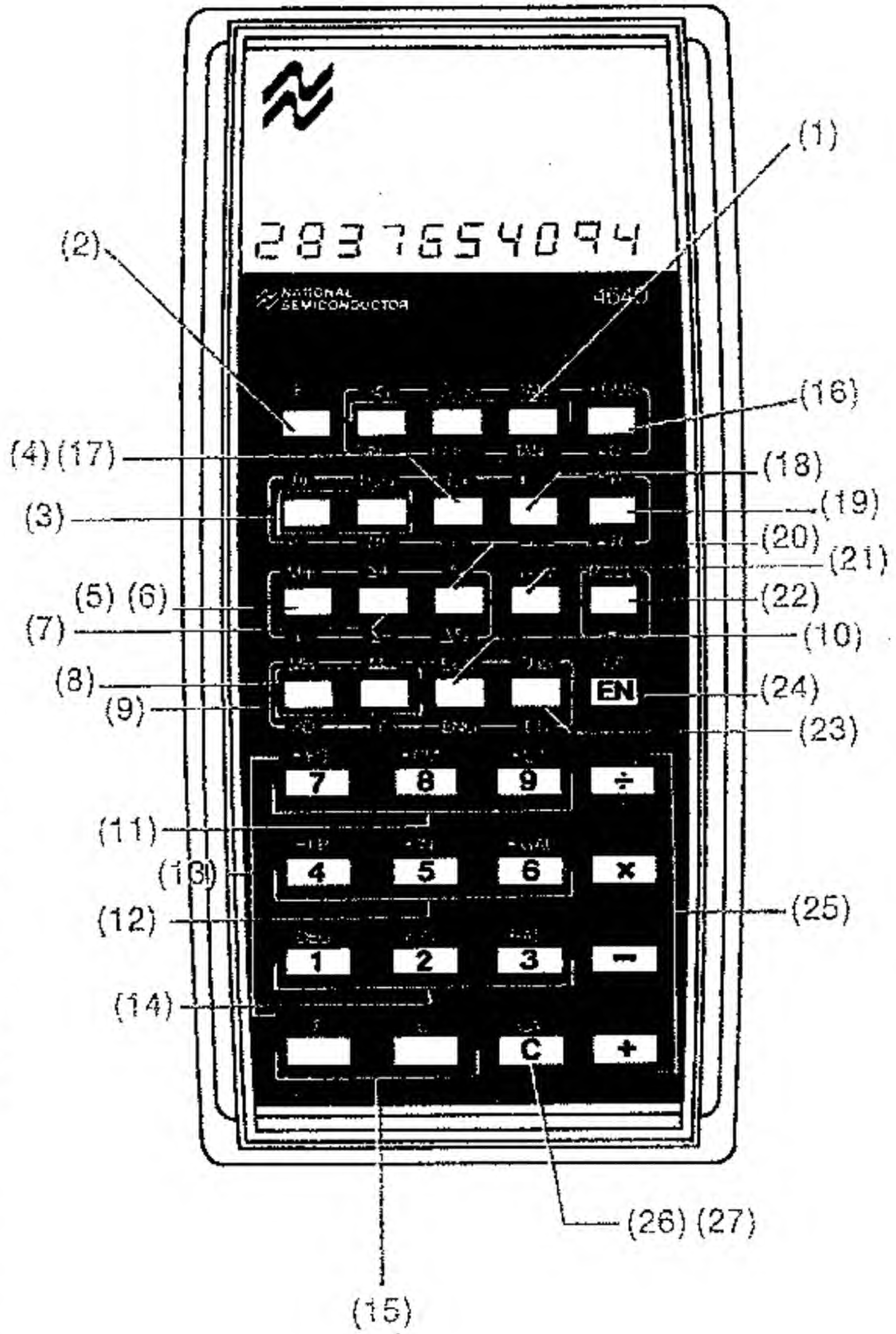
AC Charger

Your calculator is powered by rechargeable NiCad batteries. The machine will light an 'L' on the left side of the display as a low battery indicator. Although calculations can still be made while the low battery indicator is on, the battery should be charged as soon as possible. Continued use on a weak battery may result in inaccurate answers. To charge the battery, connect the AC charger to the jack at the top of the machine. A full charge takes five hours and lasts approximately five hours. You can use your machine while the charger is plugged in. The machine will not overcharge. It is advisable to charge your calculator each night. BE SURE TO TURN YOUR CALCULATOR OFF BEFORE CONNECTING THE AC CHARGER.

Keyboard Layout

Most of the keys on your calculator perform two functions. The primary functions are printed on top of the keys. They will be represented in this manual by the function key itself (e.g. M+). Secondary functions are printed in front of the key. They will be represented in this manual by the Second Function key followed by the function key (e.g. F x!) indicating that the Second Function key (F) must be touched before the function key (x!). If F has been touched accidentally, touching CF will cancel the effect of the F key.

Keyboard Layout



1 Trigonometric function keys
2 Second function key
3 Logarithmic function keys
4 Power & root key
5 Accumulating memory key
6 Factorial key
7 Summation keys
8 Memory function keys
9 Statistical function keys
10 Enter exponent & engineering notation key
11 Metric conversion keys
12 U.S. conversion keys
13 Number entry keys
14 Angular mode keys
15 Temperature conversion keys
16 Degrees, minutes & seconds conversion key
17 Reciprocal key
18 Square root & square key
19 Rectangular to polar conversion key
20 Percent function key
21 Exchange key
22 Roll & Pi entry key
23 Change sign & decimal set key
24 Enter & clear second function key
25 Basic function keys
26 Clear entry key
27 Clear all key

Keying in Numbers

Key in numbers by touching the number keys in the same sequence as if you were writing them down on paper. If a decimal appears in the number, key it in sequence as part of the number. The calculator accepts the first decimal keyed in as the decimal in the number. The decimal need not be keyed in when keying in whole numbers.

Negative Numbers

To key in a negative number, key in the number sequence, then touch CHS.

Keying in Exponents of 10

Any number can be entered in your calculator in scientific notation, that is, as a number (mantissa) multiplied by 10 raised to a power (exponent). The exponent indicates how many places the decimal point should be moved. If the exponent is positive, the decimal point is moved to the right. If the exponent is negative, the decimal point is moved to the left. For example: 1200 can be entered as 1.2×10^3. Key in: 1 • 2 EEX 3, the display shows: 1.2 03. Note: The last two digits on the right side of the display are used to indicate exponents.

Very large and very small numbers must be entered in scientific notation. For example: 134,000,000,000,000 (written 1.34×10^{14}) must be keyed in: C (to clear for these examples), 1.34 EEX 14, display shows: 1.34 14.

To enter a negative exponent, touch CHS after keying in the exponent. For example: .000000000034 (written 3.4×10^{-11}) must be keyed in: C 3 • 4 EEX 11 CHS, display shows: 3.4 −11.

If EEX has not been preceded by a mantissa entry, the mantissa is entered as 1.

To correct a wrong exponent entry, simply key in the right exponent. The calculator accepts the last two digits keyed in as the exponent. Touching • after EEX cancels the effect of touching EEX.

Entering Pi

To key in the constant Pi ($\pi = 3.141592654$) simply touch the F π key.

Clearing

To clear the number in the display, touch C. If there was another number or an intermediate result in the calculator, that number will appear in the display. To clear the entire calculator (including memories) touch F CA.

Your calculator displays a 10-digit mantissa and 2-digit exponent. The calculator will accept and display numbers from $\pm 9.999999999 \times 10^{99}$ to $\pm 1 \times 10^{-99}$. All calculations, however, are computed internally using 12 mantissa digits to insure accuracy. Thus, while you see the constant Pi in the display as 3.141592654, internal computations are done using Pi = 3.14159265359.

Display Control Keys

When your calculator is first switched on, the display shows numbers in *floating point* format. Numbers between ±.1 and 9999999999. appear with all digits present and the decimal place correctly positioned. With the display control keys, the display can be controlled to alter the manner in which the numbers are shown. Remember that no matter what format you select for your displayed numbers, the format affects the *display* only and not the internal number. It is always calculated using 12 mantissa digits.

F DS n Formats the display to show *fixed point* format with automatic roundoff. n = 0 through 9.

For example, switching the calculator on and keying in: F π displays: 3.141592654. Now, key in: F DS 4 the display now shows 3.1416, four decimal places rounded at the fourth decimal place.

F DS • Formats the display to *floating point* format.

For example, key in: F DS • , the display now shows 3.141592654, returning to full floating point from four-place decimal roundoff.

Numbers smaller than .1 or larger than 9999999999. are automatically converted to scientific notation format. Scientific notation format numbers are displayed as a mantissa with a 1-digit characteristic (number to left of the decimal) times 10 to a power.

F ENG Formats the display in engineering notation format. Numbers are displayed as a mantissa with a 1- to 3-digit characteristic times 10 raised to a power that is a multiple of 3.

For example, key in: 22334455 • 66 EN , the display now shows: 22334455.66. Now, key in: F ENG , the display shows: 22.33445566 06, indicating that this is 22.33445566×10^6. This format is especially useful in scientific and engineering calculations where units are often expressed with prefixes that stand for multiples of three. For example, see the following chart:

ENGINEERING SYMBOL	PREFIX NAME	EXPONENT OF 10
T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
k	kilo	10^{3}
m	milli	10^{-3}
µ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}

Overflow and Error Indicators

Any result larger than $9.999999999 \times 10^{99}$ or smaller than $1. \times 10^{-99}$ or any logic errors (e.g. division by zero) will result in the error indicator ERROR being displayed. Touching C will clear the error and let you continue calculation. Touching any other key permits continuation of the calculation with the calculator assuming that the contents of the display are zero.

Low Battery Indicator

Your calculator will display an 'L' in the left side of the display if the battery needs recharging. (See section on AC Charger).

Change Sign

Touching CHS any time except after EEX will

change the sign of the mantissa portion of the number in the display. Touching CHS after EEX changes the sign of the exponent being keyed in.

Performing Calculations

You will find calculations simple on your machine if you keep one all encompassing rule in mind:
A function is performed the moment that function key is touched.

One-Factor Functions

These are functions that only require one number for an operation to be performed. The function is performed immediately on the number in the display.
To use a one-factor function, key in the number, then touch the desired function key. For example, to find the square root of 16, key in: F DS • (return to floating point format) 16 √ display shows 4.

Two-Factor Functions

These are functions that require two numbers for an operation to be performed. Two-factor functions work the same way that one-factor functions work, that is, the function is performed the moment the function key is touched. Therefore, *both* numbers must be in the machine before the function key is touched. To get the first number in the calculator, key in the number, then touch EN . Key in the second number, then touch the desired function key . . . the function is performed. For example, to multiply 5 x 3: key in: 5 EN 3 X , the display shows 15. The function, in this case multiplication, was performed the moment the X key was touched.

Reverse Polish Logic and the Stack Principle

Your calculator uses the most effective logic system known to science, Reverse Polish Notation, a system invented by the Polish mathematician Jan Lukasiewicz. The machine uses Reverse Polish Notation

(RPN) in conjunction with four registers called X, Y, Z and T. A register is an electronic element used to store data while it is being displayed, processed or waiting to be processed.

The Stack

The four registers are arranged in a 'stack' as follows: (To avoid confusion between the name of a register and its contents, the registers in this diagram, this instruction book and the diagrams in Appendix A are represented by capital letters X, Y, Z and T while the contents of the registers are represented by lower-case letters x, y, z and t).

CONTENTS	LOCATION
t	T
z	Z
y	Y
x	X

The display always shows the contents (x) of register X. Although the display may be formatted, internally the contents of register X are always 12 mantissa digits. See Appendix A for stack diagrams for each operation on your calculator.

Controlling the Stack

The following stack control keys allow you to control the stack for reviewing stack contents or shifting data within the stack for calculations.

ROLL Touching this key 'rolls' the contents of the stack from one register to another. The contents (x) of register X 'roll' to register T, the contents (t) of register T 'roll' to register Z, the contents (z) of register Z 'roll' to register Y and the contents (y) of register Y 'roll' to register X. Touching ROLL four times will bring the stack contents back to their original stack positions.

x-y Touching this key exchanges the contents (x) of register X with the contents (y) of register Y.

To see how the ROLL and x–y keys work, fill the stack up by keying in: 4 EN 3 EN 2 EN 1.
The contents of the stack now look like this:

	CONTENTS	LOCATION
	4	T
	3	Z
	2	Y
Display shows:	1	X

Touching ROLL will change the stack to look like this:

	CONTENTS	LOCATION
	1	T
	4	Z
	3	Y
Display shows:	2	X

Touching ROLL again will change the stack to look like this:

	CONTENTS	LOCATION
	2	T
	1	Z
	4	Y
Display shows:	3	X

Touching x–y will change the stack to look like this:

	CONTENTS	LOCATION
	2	T
	1	Z
	3	Y
Display shows:	4	X

Clearing the Stack

Touching C clears the X register and drops the stack down. Touching C will change the stack to look like this:

	CONTENTS	LOCATION
	0	T
	2	Z
	1	Y
Display shows:	3	X

Touching C four times will clear the entire stack. *Touching F CA clears the entire stack at once as well as all memories.*

One-Factor Calculations and the Stack

One-factor calculations affect the X register only. The rest of the stack is undisturbed. Keying in 30 will change the stack to look like this:

	CONTENTS	LOCATION
	2	T
	1	Z
	3	Y
Display shows:	30	X

Touching sin (a one-factor function) will change the stack to look like this:

	CONTENTS	LOCATION
	2	T
	1	Z
	3	Y
Display shows:	.5	X

Note: *If an overflow or logic error is made using a one-factor function, the* Error *indicator will be displayed and the calculator will clear register X to zero. No other registers are affected.*

Entering Numbers

After keying in a number, touching EN copies the number from the display (register X) to register Y and pushes the stack up. The number at the top of the stack (register T) is lost. Keying in 20 EN will change the stack to look like this:

Keying in 20:

CONTENTS	LOCATION
1	T
3	Z
.5	Y
Display shows: 20	X

Touching EN:

CONTENTS	LOCATION
3	T
.5	Z
20	Y
Display shows: 20	X

Touching EN prepares the X register for a new number which replaces the number currently in register X. Keying in 5 will change the stack to look like this:

CONTENTS	LOCATION
3	T
.5	Z
20	Y
Display shows: 5	X

Note that the stack is *moved up* in two ways:

1. Touching EN.
2. Keying in a number after touching a function key.

Two-Factor Calculations and the Stack

To perform a two-factor calculation, key in the first number, touch EN, key in the second number and touch the desired function key. Remember that the function is performed the moment the function key is touched. Touching ÷ at this point will perform a division and drop the stack. The stack will look like this:

CONTENTS	LOCATION
0	T
3	Z
.5	Y
Display shows: 4	X

Note that the stack is *dropped* in two ways:

1. Touching C.
2. Performing a two-factor function.

Note: *If an overflow or logic error is made using a two-factor function, the* Error *indicator will be displayed and the calculator will clear register X to zero. No other register is affected.*

Basic Function Keys

The 'basic' two-factor functions are +, −, × and ÷. They work on the contents of registers X and Y.

+ Adds 'x' to 'y'.
− Subtracts 'x' from 'y'.
× Multiplies 'y' by 'x'.
÷ Divides 'y' by 'x'.

Mathematical Hierarchy and RPN

Hierarchy is a term for the rules of mathematics that govern the order in which operations are performed on numbers. They are the 'pecking order' of math. Operations are performed in the following order:

1. Raising to powers, taking roots, trig, log and reciprocal functions.
2. Multiplication and division.
3. Addition and subtraction.

If there are parentheses in the equation, they should be thought of as single numbers. Solve the calculation within the parentheses according to the rules of hierarchy to get that single number. For example: the equation $(3^2+2)4+\sin 30 \div \sqrt{25}$ is solved according to the rules of hierarchy as follows:

$$\underbrace{\underbrace{\underbrace{(\underbrace{3^2}_{1}+2)}_{2}\quad 4}_{3} \quad + \quad \underbrace{\underbrace{\sin 30}_{4} \quad \div \quad \underbrace{\sqrt{25}}_{5}}_{6}}_{7}$$

1. $3^2=9.$
2. $9+2=11.$
3. $11 \times 4=44.$
4. $\sin 30=.5$
5. $\sqrt{25}=5.$
6. $.5 \div 5=.1$
7. $44+.1=44.1$ — the solution to the equation. The solution was found according to the rules of hierarchy and therefore is mathematically correct.

Most calculations can be done on your calculator by remembering the following three steps in applying RPN to the rules of hierarchy:

1. Starting at the left and working right, key in the next number (or first if this is the beginning of a new problem).
2. Ask yourself: "Can an operation be performed according to the rules of hierarchy?" If so, perform all operations possible; if not, touch EN.
3. Repeat steps 1 and 2 until the calculation is complete.

Following these three steps, you can calculate the example equation $(3^2+2)4+\sin 30 \div \sqrt{25}$ using RPN as follows:

KEY IN	DISPLAY SHOWS	COMMENTS
3	3.	
F x^2	9.	3^2
2	2.	
+	11.	(3^2+2)
4	4.	
×	44.	$(3^2+2)\,4$
30	30.	
sin	.5	sin 30
25	25.	
$\sqrt{\ }$	5.	$\sqrt{25}$
÷	.1	$\sin 30 \div \sqrt{25}$
+	44.1	$(3^2+2)4+\sin 30 \div \sqrt{25}$

The calculation is complete and performed according to the rules of hierarchy.

Chain Calculations

The number in the display is always ready to have functions performed on it. Therefore, to do chain calculations, simply perform the next operation. The previous example equation is an example of a chain calculation.

Although most problems can be handled in the left to right manner described in the section on hierarchy, engineers and scientists have found that for extremely complicated equations, or those with a great many levels of parentheses, the optimum method of solving these equations is to start with the innermost set of parentheses and work outward, following the rules of hierarchy. For example, the equation for an Iris-coupled wave guide junction is given as:

$$Q_u \frac{\delta}{\lambda} = [(ABL) \div 2] \times \left\{ \sqrt{(p^2+p^2)^3} \div [p^2 \times B(A+2L) + q^2 \times A(B+2L)] \right\}$$

given A = 4, B = 2, L = 8, p = .25 and q = .5,

$$= [(4 \times 2 \times 8) \div 2] \times \left\{ \sqrt{(.25^2 + .5^2)^3} \div [.25^2 \times 2(4+2 \times 8) + .5^2 \times 4(2+2 \times 8)] \right\}$$

Working from the innermost set of parentheses out:

KEY IN	DISPLAY SHOWS	COMMENTS
2 EN 8 × 4 +	20.	(A + 2L)
2 × .25 F x² ×	2.5	$p^2 \times B(A+2L)$
2 EN 8 × 2 +	18.	(B + 2L)
4 × .5 F x² × +	20.5	$[p^2 \times B(A+2L) + q^2 \times A(B+2L]$
.25 F x² .5 F x²		
+ 3 F yˣ √	.1746928107	$\sqrt{(p^2+q^2)^3}$
x⇄y ÷	8.521600524 −03	$\{\sqrt{(p^2+q^2)^3} \div [p^2 \times B(A+2L) + q^2 \times A(B+2L]\}$
4 EN 2 × 8 ×	64.	(ABL)
2 ÷ ×	.2726912168	$[(ABL) \div 2] \times \{\sqrt{(p^2+q^2)^3} \div [p^2 \times B(A+2L) + q^2 \times A(B+2L)]\}$

The calculation is complete and performed according to the rules of hierarchy. While most problems will not be as complicated as the above example, it illustrates the ease and simplicity with which your machine can handle even the most complex equations.

In addition to the four-level stack, your calculator has three fully addressable separate memory storage registers called M1, M2 and M3. You can picture them in addition to the stack like this:

	STACK Contents	STACK Location	MEMORY Contents	MEMORY Location
	t	T	m1	M1
	z	Z	m2	M2
	y	Y	m3	M3
Display:	x	X		

Storing and Recalling Numbers

To store a number, key in the number and touch MS n, where n = 1, 2 or 3. If the number you want to store is already in the display, just touch MS n. For example, to store the gravitational acceleration constant (g = 32.174 ft/sec²) in memory register 2, key in: F CA (to clear the stack and all memory registers for this example) 32 • 174 MS 2. The stack and memory now look like this:

	STACK Contents	STACK Location	MEMORY Contents	MEMORY Location
	0	T	0	M1
	0	Z	32.174	M2
	0	Y	0	M3
Display:	32.174	X		

Notice that touching MS n merely copies the contents of the display to memory register n. *It does not affect the stack*, or any operations taking place in the stack. Touching MS n at any time will store the contents of the display in memory register n without affecting the calculation in progress. For example, store the result of 5 x 4 in memory register 1. Key in: 5 EN 4 × MS 1; the stack now looks like this:

STACK Contents	STACK Location
0	T
0	Z
32.174	Y
Display: 20	X

MEMORY Contents	MEMORY Location
20	M1
32.174	M2
0	M3

To recall a number from memory to the display, touch MR n, where n = 1, 2 or 3. The number will be copied to the X register. For example, recall the gravitational acceleration constant from memory register 2. Key in: MR 2; the stack now looks like this:

STACK Contents	STACK Location
0	T
32.174	Z
20	Y
Display: 32.174	X

MEMORY Contents	MEMORY Location
20	M1
32.174	M2
0	M3

Notice that touching MR n copies the contents of memory register n to the display and pushes the stack up, the same as if a number had been keyed in.

Clearing Memory Registers

To clear a memory register, key in 0 MS n, where n = 1, 2 or 3. For example, keying in: 0 MS 1 will make the stack look like this:

STACK Contents	STACK Location
32.174	T
20	Z
32.174	Y
Display: 0	X

MEMORY Contents	MEMORY Location
0	M1
32.174	M2
0	M3

Note that keying in 0 MS n also puts a zero in register X. You can clear all three memory registers at once by touching F CA. Be careful, however, as this clears the entire stack, too.

Direct Register Arithmetic

Touching MS followed by a basic function key followed by a memory register address n, where n = 1, 2 or 3 performs arithmetic *directly upon the contents of memory register n.*

MS + n — Adds the contents of the display to the contents of memory register n.

MS − n — Subtracts the contents of the display from the contents of memory register n.

MS × n — Multiplies the contents of memory register n by the contents of the display.

MS ÷ n — Divides the contents of memory register n by the contents of the display.

The result of the arithmetic operation is always returned to memory register n. *It does not affect the display (register X) or the rest of the stack.*

For example, put 5 into all three memory registers. Key in: F CA (clear all for this example) 5 MS 1 MS 2 MS 3; the stack now looks like this:

STACK Contents	STACK Location
0	T
0	Z
0	Y
Display: 5	X

MEMORY Contents	MEMORY Location
5	M1
5	M2
5	M3

Now, add 4 to memory register 1, multiply memory register 2 by 4 and divide memory register 3 by 4. Key in: 4 MS + 1 MS × 2 MS ÷ 3; the stack now looks like this:

STACK Contents	STACK Location
0	T
0	Z
5	Y
Display: 4	X

MEMORY Contents	MEMORY Location
9	M1
20	M2
1.25	M3

Automatic Accumulating Memory

The contents of the display can be automatically added to the contents of memory register 1 by touching the M+ key. For example, accumulate the sum of the following products in memory register 1: (2 x 3) + (4 x 5) + (6 x 7). The stack will look like this:

Key in: F CA (clear all for this example) 2 EN 3 X M+,

STACK

	Contents	Location
	0	T
	0	Z
	0	Y
Display:	6	X

MEMORY

Contents	Location
6	M1
0	M2
0	M3

key in: 4 EN 5 X M+,

STACK

	Contents	Location
	0	T
	0	Z
	6	Y
Display:	20	X

MEMORY

Contents	Location
26	M1
0	M2
0	M3

key in: 6 EN 7 X M+,

STACK

	Contents	Location
	0	T
	6	Z
	20	Y
Display:	42	X

MEMORY

Contents	Location
68	M1
0	M2
0	M3

Exchanging Memory Register Contents

Touching MS x-y n, where n = 1, 2 or 3, exchanges the contents of the display (register X) with the contents of memory register n. For example, keying in MS x-y 1, will make the stack look like this:

STACK

	Contents	Location
	0	T
	6	Z
	20	Y
Display:	68	X

MEMORY

Contents	Location
42	M1
0	M2
0	M3

Memory Overflow

If performing a direct arithmetic operation on a memory register results in an overflow in the memory register, the ERROR indicator is displayed, the contents of register X are copied into the memory register that overflowed, and register X is cleared to zero. The error condition is cleared the same as any other error or overflow condition. (See the section on overflow and error indicators).

Angular Mode Selection

When your calculator is first switched on, the angular mode is automatically set to decimal degrees mode. That is to say, all trigonometric functions as well as rectangular to polar coordinate conversions will be computed in decimal degrees. You can, however, change the angular mode from degrees to grads or radians and back again.

Note: *360 degrees = 400 grads = 2π radians.*

F GRAD Changes angular mode to grads

F DEG Changes angular mode to decimal degrees.

F RAD Changes angular mode to radians.

To convert from one angular mode to another, see the section on angular mode conversions following trigonometric functions.

sin	Computes the sine of the angle in the display.
F sin^{-1}	Computes the arc sine of the number in the display.
cos	Computes the cosine of the angle in the display.
F cos^{-1}	Computes the arc cosine of the number in the display.
tan	Computes the tangent of the angle in the display.
F tan^{-1}	Computes the arc tangent of the number in the display.

For example: Compute the sine of 45 degrees. Switch your machine off then back on, thus setting the angular mode automatically to degrees. Key in: 45 sin, display shows .7071067812. Now, calculate the cosine of 2.2 radians. Key in: F RAD 2 • 2 cos, display shows −.5885011173.

Note: *The calculator remains in the angular mode last selected until a new angular mode is selected.*

Angular Mode Conversions

Converting angles (for example, from degrees to grads) is done by computing a trigonometric function in one mode, switching modes, then computing the inverse trigonometric function. For example, how many grads is 45 degrees? Key in: F DEG 45 sin F GRAD F sin^{-1}. Display shows: 50. Hence, 45 degrees = 50 grads. How many degrees is 1 radian? Key in: F RAD 1 sin F DEG F sin^{-1}. Display shows: 57.29577951. Hence, 1 radian = 57.29577951 degrees.

Note: Conversions come back in *principle angles only.* (For example, 850 grads – principle angle = 50 – converts back to 45 degrees, not 765).

DMS	Touching DMS converts the number in the display from decimal degrees (a decimal number, e.g. 34.887668) to degrees, minutes and seconds (DMS). DMS format is in the form dd.mmss where dd = degrees, mm = minutes and ss = seconds. DMS format is rounded to four decimal places (e.g. 34.5316).

For example, to convert 45.98852 degrees to degrees, minutes and seconds, key in: 45 • 98852 DMS, display shows: 45.5919, indicating 45°59′19″ (45 degrees, 59 minutes, 19 seconds).

F D	Touching F D converts the number in the display from degrees, minutes and seconds to decimal degrees.

This is a handy function in that your calculator computes trigonometric functions in *decimal degrees* and not degrees, minutes and seconds. For example, compute the tangent of 56°42′16″. Key in: 56 • 4216 F D F DEG tan ; display shows: 1.5226. Remember: DMS automatically sets 4-place decimal roundoff. To see a full floating answer, touch: F DS • ; display shows: 1.522611881.

Calculations with Time

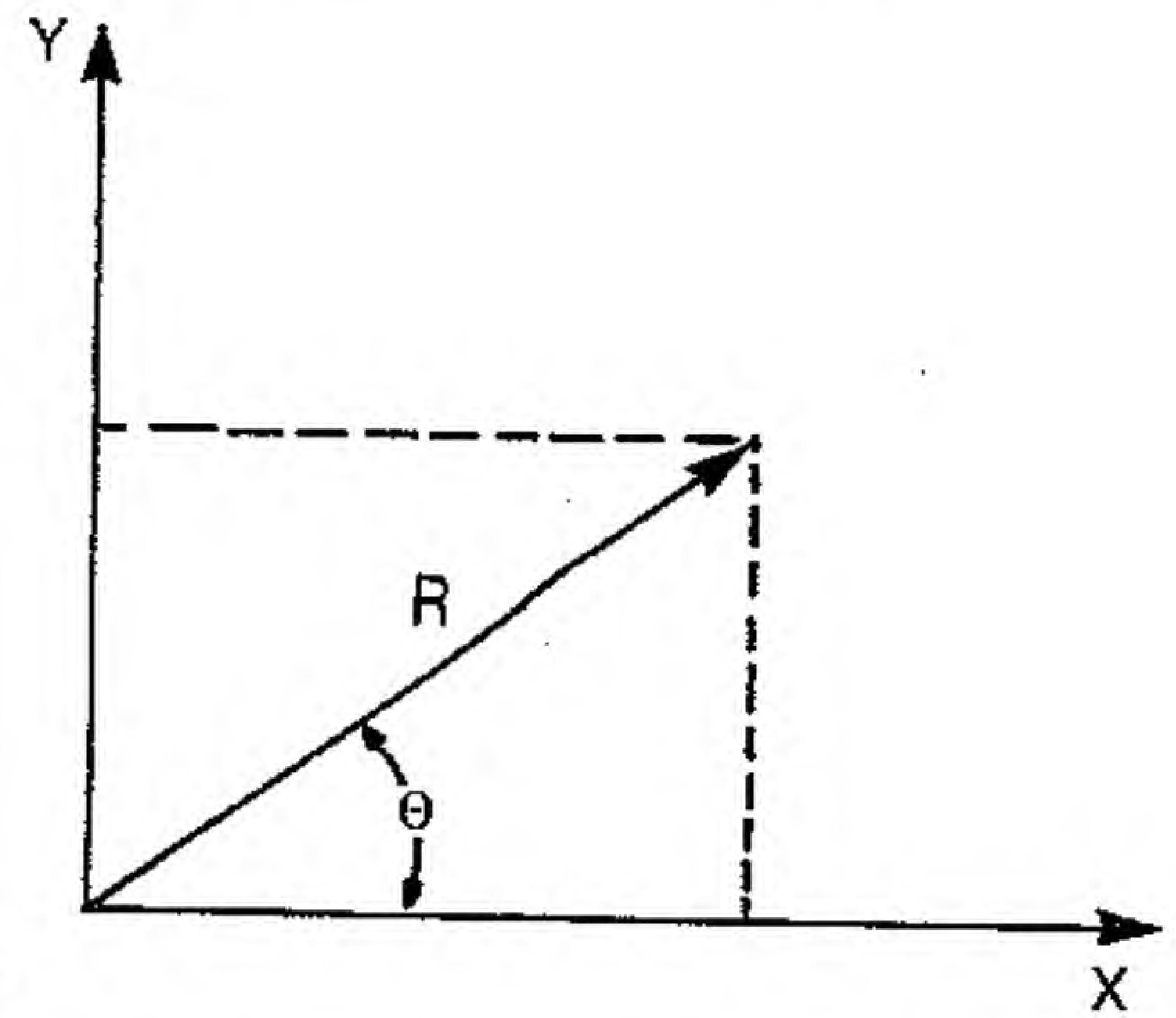
The F D and DMS keys are especially useful in calculations dealing with time. Hours, minutes and seconds correspond to degrees, minutes and seconds, therefore, the F D and DMS keys can be used to convert hours, minutes and seconds (HMS) to decimal hours and back. For example, will three works of music, one lasting 1 hour, 14 minutes, 43 seconds, the second lasting 36 minutes, 22 seconds and the third lasting 1 hour, 9 minutes and 2 seconds fit on a three-hour tape?

KEY IN	DISPLAY SHOWS	COMMENTS
F CA	0.	Clear the calculator.
1.1443 F D M+	1.245277778	Convert HMS to decimal hours and accumulate in memory 1.
.3622 F D M+	.6061111111	Convert and accumulate.
1.0902 F D M+	1.150555556	Convert and accumulate.
MR 1 DMS	3.0007	Recall accumulated decimal hours and convert to HMS. The tape is 7 seconds short!

For example, how many manhours are expended if 17 people work on a project for 2 hours and 15 minutes? Key in: 2 • 15 F D 17 X ; display shows: 38.2500 — 38.25 decimal man-hours, or, touching DMS, display shows: 38.1500 — 38 man-hours, 15 man-minutes.

Rectangular/Polar Coordinate Conversions

→P Converts the rectangular coordinates x and y stored in registers X and Y, respectively, to the polar coordinates R and Θ.



The angle, Θ, is returned to the X register, and the magnitude, R, is returned to the Y register. For example, convert the rectangular coordinates $x = 8$, $y = 6$, to polar coordinates R and Θ. Key in: F DEG F DS • 6 EN 8 →P ; display shows: 36.86989765 (Θ), touching x⇌y, display shows: 10. (R).

F →R Converts the polar coordinates R (stored in register Y) and Θ (stored in register X) to rectangular coordinates x and y.

The x-coordinate is returned to register X, and the y-coordinate is returned to register Y. For example, convert the polar coordinates $R = 8.5$, $\Theta = 60°$ to rectangular coordinates x and y. Key in: 8 • 5 EN 60 F →R ; display shows: 4.25 (x). Touching x⇌y, display shows: 7.361215932 (y).

Remember that the rectangular/polar conversion function works with Θ using the last angle mode that was set.

Squaring and Square Root

√ Computes the square root of the number in the display.

F x^2 Computes the square of the number in the display.

For example, to square 5.43, key in: 5 • 43 F x^2 ; display shows: 29.4849.

Reciprocals

1/x Computes the reciprocal of the number in the display (divides 1 by the number in display).

For example, what is the equivalent resistance of a 220-ohm risistor, a 145-ohm resistor and a 175-ohm resistor connected in parallel if the following equation applies?

$$R_{eq} = \frac{1}{1/R_1 + 1/R_2 + 1/R_3}.$$

Key in: 220 1/x 145 1/x + 175 1/x + 1/x ; display shows: 58.28765335.

F y^x Raises a positive integer or decimal number (x) to any positive or negative, integer or decimal power—in other words, raises 'y' to the 'x' power.

For example, compute 5^3 (i.e. 5 x 5 x 5). Key in: 5 EN 3 F y^x; display shows: 125. Now, compute $8.22^{-2.34}$. Key in: 8 • 22 EN 2 • 34 CHS F y^x; display shows: 7.231026397 −03.

1/x F y^x Computes the positive or negative, integer or decimal root of any positive integer or decimal number—in other words, computes the 'x'th root of 'y'. Since taking the x^{th} root of a number is the same as raising that number to the 1/x power, using the 1/x key in conjunction with F y^x key provides a simple way to extract roots.

For example, compute the cube root of 125 (i.e. $\sqrt[3]{125} = 125^{1/3}$). Key in: 125 EN 3 1/x F y^x; display shows: 5. Now compute the −5.4th root of 226.2 (i.e. $\sqrt[-5.4]{226.2}$). Key in: 226 • 2 EN 5 • 4 CHS 1/x F y^x; display shows: .366423106.

Logarithmic Functions

LOG Computes the common log (i.e. log to the base 10 = $\log_{10}$) of the number in the display.

For example, compute the common log of 45.67 = $\log_{10}$ 45.67. Key in: 45 • 67 LOG; display shows: 1.659631012.

F 10^x Computes the common antilog of the number in the display. That is to say, it raises 10 to the 'x'th power.

For example, what is the common antilog of 2.77 = antilog_{10} 27.7? Key in: 2 • 77 F 10^x; display shows: 588.8436554. Now, what is 10^5? Key in: 5 F 10^x; display shows: 100000.

ln Computes the natural log (i.e. log to the base e, e = 2.718281828) of the number in the display.

For example, compute the natural log of 5 = ln 5 (ln stands for *Log Natural*). Key in: 5 ln; display shows: 1.609437912. Now, find out how many years it will take $4600 to grow to $15,000 at an annual interest rate of 8.5% if the following formula is applicable: n = ln(FV ÷ PV) ÷ ln(1+i), where n = number of years, FV = future value ($15,000), PV = present value ($4600) and i = interest rate/year (8.5%):

KEY IN	DISPLAY SHOWS	COMMENTS
F DS 2		Round display to 2 places.
15000 EN		
4600 ÷	3.26	(FV ÷ PV)
ln	1.18	ln(FV÷PV)
1.085 ln ÷	14.49	ln(FV÷PV) ÷ ln(1+i). It will take approximately 14½ years.

F e^x Computes the natural antilog of the number in the display. That is, it raises e = 2.718281828 to the 'x'th power.

For example, given that the half-life of a radioactive substance is 10 minutes, how much of a given sample of 5 grams will remain undecomposed after 20 minutes if the following decay formula is applicable?:

$$g = 5e^{-kt}.$$

First we must find k. From the given data: $½ = e^{-10k}$, taking the natural log of both sides, we have k = ln 2/10; substituting back, we find: $y = 5e^{-(\ln 2 \div 10) \times 20}$. When t = 20 minutes, we have: $y = 5e^{-(\ln 2 \div 10) \times 20}$.

KEY IN	DISPLAY SHOWS	COMMENTS
F DS •		Set display to floating point.
2 ln 10		
÷ 20 ×	1.386294361	(ln 2 ÷ 10) x 20
CHS F e^x		$5e^{-(\ln 2 \div 10) \times 20}$.
5 ×	1.25	There are 1.25 grams of the substance left.

% Computes 'x' percent of 'y'. Touching % replaces the contents of register X with $\frac{'x' \times 'y'}{100}$

For example: What is 15% of 200?
Keying in: F CA (clear the stack for this example)
200 EN 15 %, will make the stack look like this:

	CONTENTS	LOCATION
	0	T
	0	Z
	200	Y
Display:	30	X = 15% of 200.

Multiplying and Dividing by Percentages

Because the percentage of the base number 'y' is returned to register X, touching × or ÷ allows you to multiply or divide the base 'y' by the percentage. For example, touching × will make the stack look like this:

	CONTENTS	LOCATION
	0	T
	0	Z
	0	Y
Display:	6000	X = 200 x 15% of 200 (200 x 30).

'Add-on' and 'Discount' Calculations

Because the percentage of the base number 'y' is returned to register X, touching + or − allows you to add on or subtract the percentage from the base number. For example: How much would you pay for a stereo costing $475.00 if there was 6.5% sales tax? Key in: F DS 2 475 EN 6 • 5 %, and the stack looks like this:

	CONTENTS	LOCATION
	0	T
	6000.00	Z
	475.00	Y
Display:	30.88	X = 6.5% of $475, = tax.

Key in: +, and the stack looks like this:

	CONTENTS	LOCATION
	0	T
	0	Z
	6000.00	Y
Display:	505.88	X = $475 + 6.5% of $475, = price. (475 + 30.88).

Amount and Percent Change Calculations

F Δ% Computes the percent difference and actual difference between the number in register X and the number in register Y. Touching F Δ% replaces the contents of register X with 'y'−'x'/'x' x 100 (the percent difference) and replaces the contents of register Y with 'y'−'x' (the actual difference).

For example, if sales this month were $450 and sales last month were $310, what is the percent increase and actual increase in sales? Key in: 450 EN 310 F Δ%, and the stack looks like this:

	CONTENTS	LOCATION
	6000.00	T
	505.88	Z
	140.00	Y = actual difference (450 − 310).
Display:	45.16	X = percent difference (450 is a 45.16% increase over 310, or $\frac{450-310}{310}$ x 100).

The percent difference is displayed. To see the actual difference, touch x⇄y ; display shows: 140.00.

Computing Percentages

For example, what percent of 310 is 186? Key in: 186 EN 310 F Δ% 100 + ; display shows: 60.00 (186 is 60% of 310).

Statistical Functions

Summations

Σ+ This key is used to enter data points for computing means and standard deviations.

Touching Σ+ does the following things:

1. Sums x in memory register M1 (Σx),
2. Sums x^2 in memory register M2 (Σx^2),
3. Adds 1 to memory register M3 (n-count).

The data point keyed in remains in register X allowing for multiple data point entries (repeat summation) by simply touching Σ+ .

Because the calculator uses memory registers M1, M2 and M3 for summations, make sure that you clear the memory registers before beginning any new calculations using the Σ+ *key.* If you do not need the contents of the rest of the stack, key in F CA . If you do need the contents of the rest of the stack, key in 0 MS 1 MS 2 MS 3. For example, find Σx and Σx^2 for the following data points: 2, 5, 7, 3, 2. Key in: F DS • F CA 2 Σ+ , and the stack looks like this:

	STACK Contents	STACK Location	MEMORY Contents	MEMORY Location
	0	T	2	M1 = Σx
	0	Z	4	M2 = Σx^2
	0	Y	1	M3 = n-count.
Display:	2	X		

Key in: 5 Σ+ , and the stack looks like this:

	STACK Contents	STACK Location	MEMORY Contents	MEMORY Location
	0	T	7	M1 = Σx
	0	Z	29	M2 = Σx^2
	2	Y	2	M3 = n-count.
Display:	5	X		

Key in: 7 Σ+ , and the stack looks like this:

	STACK Contents	STACK Location	MEMORY Contents	MEMORY Location
	0	T	14	M1 = Σx
	2	Z	78	M2 = Σx^2
	5	Y	3	M3 = n-count.
Display:	7	X		

Key in: 3 Σ+ , and the stack looks like this:

	STACK Contents	STACK Location	MEMORY Contents	MEMORY Location
	2	T	17	M1 = Σx
	5	Z	87	M2 = Σx^2
	7	Y	4	M3 = n-count.
Display:	3	X		

Key in: 2 Σ+ , and the stack looks like this:

	STACK Contents	STACK Location	MEMORY Contents	MEMORY Location
	5	T	19	M1 = Σx
	7	Z	91	M2 = Σx^2
	3	Y	5	M3 = n-count.
Display:	2	X		

Touch MR 1; display shows: 19 (Σx). Touch MR 2; display shows: 91 (Σx^2). Touch MR 3; display shows: 5 (n-count).

Computing Means

Touching F $\bar{x}$ computes the mean (average) of the data summed using the Σ+ key. The contents of M3 are divided by the contents of M1 and the result returned to register X (x = m1/m3). Now, touch F $\bar{x}$, and the stack looks like this:

STACK

Contents	Location
2	T
19	Z
91	Y
Display: 3.8	X = $\bar{x}$

MEMORY

Contents	Location
19	M1
91	M2
5	M3

Computing Standard Deviations

Touching F SD computes the standard deviation of the data summed using the Σ+ key. The standard deviation is computed using this formula:

$$SD = \sqrt{\frac{\Sigma x^2 - (\Sigma x)^2 \div n}{n-1}} = \sqrt{\frac{m2 - m1^2 \div m3}{m3 - 1}}$$

Now, touch F SD, and the stack looks like this:

STACK

Contents	Location
2	T
19	Z
91	Y
Display: 2.167948339	X = SD.

MEMORY

Contents	Location
19	M1
91	M2
5	M3

Note that the contents of the stack registers Y, Z and T, and the contents of memory registers M1, M2 and M3 are not affected by touching either F $\bar{x}$, or F SD.

Adding, Deleting and Correcting Data Entries

New data points can be added to the summations in the memory registers and a new mean and standard deviation computed simply by keying in the new data point and touching Σ+. For example, what is the mean and standard deviation of the following data points: 2, 5, 7, 3, 2, 8? Since only one new data point (8) was added to the list and the rest of the data points have already been summed, touch 8 Σ+ F $\bar{x}$; display shows: 4.5 (new $\bar{x}$). Touch F SD; display shows: 2.588435821 (new S.D.).

F Σ- This key is used to delete incorrect Σ+ entries. Touching F Σ- does the following things:

1. Subtracts x from the contents of register M1.
2. Subtracts x^2 from the contents of register M2.
3. Subtracts 1 from the contents of register M3.

For example, the 8 added to the list of data points in the last example was a mistake. Delete the data point and compute the original mean and standard deviation. Key in: 8 F Σ- F $\bar{x}$; display shows: 3.8 ($\bar{x}$). Touch F SD; display shows: 2.167948339 (S.D.).

If the incorrect Σ+ entry is noticed right after touching Σ+, touching F Σ- will back it right out, since the incorrect data point is still in the display. For example, find the mean and standard deviation of the following data points: 2, 7, 5, 3, 8 *(mistake!)*, 6, 2. Key in: F CA 2 Σ+ 7 Σ+ 5 Σ+ 3 Σ+ 8 Σ+ *(oops, a mistake!)* F Σ- 6 Σ+ 2 Σ+ F $\bar{x}$; display shows: 4.166666667 ($\bar{x}$), F SD; display shows 2.136976057 (S.D.).

Multiple Data Entries

Since the last data point keyed in remains in the display after touching Σ+ or F Σ-, multiple data entries can be made by repeatedly touching Σ+. For example: Compute the mean and standard deviation of the following data: 2,3.7, 3.7, 3.7, 4.6, 5.8,

5.8, 6.1, 6.1, 6.1, 7.3. Key in: F CA 2 Σ+ 3 • 7 Σ+ Σ+ Σ+ 4 • 6 Σ+ 5 • 8 Σ+ Σ+ 6 • 1 Σ+ Σ+ Σ+ 7 • 3 Σ+ F $\bar{x}$; display shows: 4.990909091 ($\bar{x}$), F SD; display shows: 1.562980835 (S.D.).

Whoops! It should have been three occurences of 2.7, not 3.7! Key in: 3 • 7 F Σ− F Σ− F Σ− 2 • 7 Σ+ Σ+ Σ+ F $\bar{x}$; display shows: 4.718181818 ($\bar{x}$), F SD; display shows: 1.853546968 (S.D.).

Factorials

F x! Computes the factorial of the number in the display (i.e. n x n−1 x n−2 x . . . x 2 x 1).

For example: compute 7 ! (= 7 x 6 x 5 x 4 x 3 x 2 x 1). Key in: 7 F x!; display shows: 5040. Factorials can be computed for any positive integer from 0 to 69. Attempting to compute the factorial of a number greater than 69, a negative number or a fractional number will result in an ERROR display.

Permutations

For example: Out of a dinner party for 10, how many ways can the hostess assign players to one table of bridge (4 positions)? The equation for permutations with random arrangement of n items taken r at a time is:

$$P(n,r) = \frac{n!}{(n-r)!} = \frac{10!}{(10-4)!}.$$

KEY IN	DISPLAY SHOWS	COMMENTS
10 F x!	3628800.	10 !
10 EN 4 − F x!	720.	(10 − 4) !
÷	5040.	Number of different positions possible.

Combinations

For example: What is the number of combinations of 24 eggs the Easter Bunny can take if he takes 7 eggs at a time? The equation for combinations with fixed arrangements of n items taken r at a time is:

$$C(n,r) = \frac{n!}{(n-r)!\,r!} = \frac{24!}{(24-7)!\,7!}.$$

KEY IN	DISPLAY SHOWS	COMMENTS
24 F x!	6.204484017 23	24 !
24 EN 7 − F x!	3.556874281 14	(24 − 7) !
7 F x! × ÷	346104.	Number of possible combinations.

Probabilities

For example, determine the probability of three 6's in five tosses of a fair die. The equation for probabliity of an event happening r times in n trials using the binominal law is: $C(n, r) \times p^r p^{n-r}$, where p = probability that an event will happen in any single trial (probability of a success) and q = (1−p) = probability that an event will not happen in any single trial (probability of a failure); hence, $P = C(5,3) \times (1/6)^3 \times (5/6)^2 = 5!/(5-3)!\,3! \times (1/6)^3 \times (5/6)^2$:

KEY IN	DISPLAY SHOWS	COMMENTS
5 F x! 5 EN 3 − F x! 3 F x! × ÷	10.	C(5,3)
6 1/x 3 F y^x ×	4.62962963 −02	$C(5,3) \times (1/6)^3$
5 EN 6 ÷ 2 F y^x ×	3.215020576 −02	$C(5,3) \times (1/6)^3 \times (5/6)^2$ = probability.

Metric Conversion Functions

F →KG Converts the number in the display from pounds to kilograms.

For example: If a French chef uses an English recipe calling for 3 pounds of sugar, how many kilograms must the chef use? Key in: 3 F →KG; display shows: 1.3607772 = kilograms of sugar used.

F →LB Converts the number in the display from kilograms to pounds.

For example: If an U.S. importer receives a 42kg shipment from Holland and the shipping charge on the American ship is 23¢ per pound, how much does the importer pay for shipping? Key in: 42 F →LB × 23 ×; display shows: 21.29665312 ($21.30—If you want the answer rounded to dollars and cents, touch F DS 2).

F →CM Converts the number in the display from inches to centimeters.

For example: If to fix a dress, a woman needs a 5-inch zipper, how many centimeters of zipper should she order from the French store? Key in: 5 F →CM; display shows: 12.7.

F →IN Converts the number in the display from centimeters to inches.

For example: If the electrical schematic for your Mercedes calls for a 45.5-cm lead wire, how many inches of wire would you need? Key in: 45 • 5 F →IN; display shows: 17.91338583.

F →LIT Converts the number in the display from U.S. gallons to liters.

For example: If a Dutch firm imports 30 gallons of California wine, how many 2-liter carafes will they need to bottle the wine? Key in: 30 F →LIT 2 ÷; display shows: 56.78118 (They need 56 carafes, and there's a little left over to drink!).

F →GAL Converts the number in the display from liters to U.S. gallons.

For example: If the Fiat you buy in Italy has a 48-liter tank capacity, how many gallons will the car hold? Key in: 48 F →GAL; display shows: 12.68025779.

F °F Converts the number in the display from degrees centigrade to degrees fahrenheit.

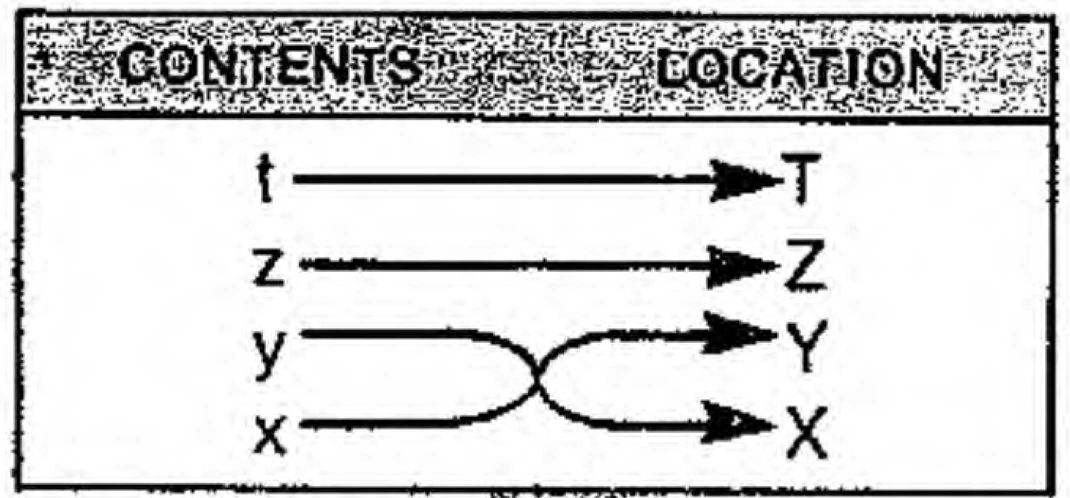
For example: If the doctor in Toronto tells you that you have a temperature of 37°C, should you worry? Key in: 37 F °F; display shows: 98.6 (No need to worry!).

F °C Converts the number in the display from degrees fahrenheit to degrees centigrade.

For example: The antifreeze sticker on your Celica says that antifreeze should be added at −35°C. If the temperature is −27°F, should you add the antifreeze? Key in: 27 CHS F °C; display shows: −32.77777778 (Close, but not quite!).

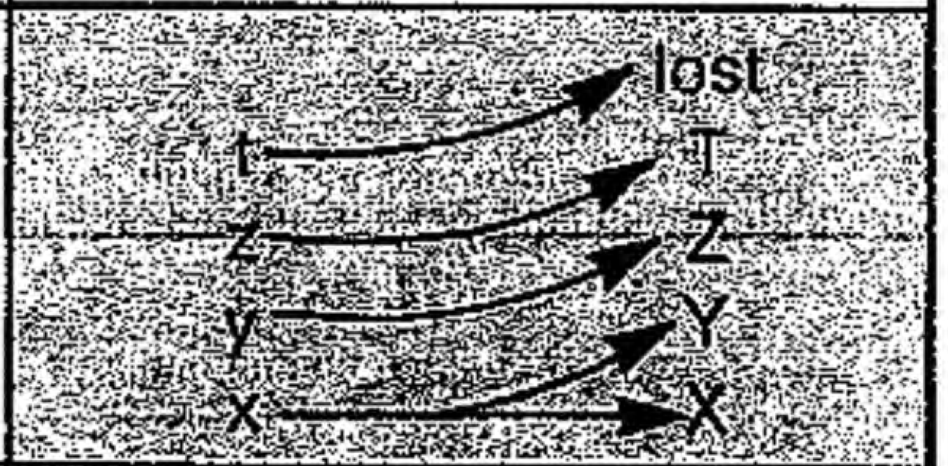
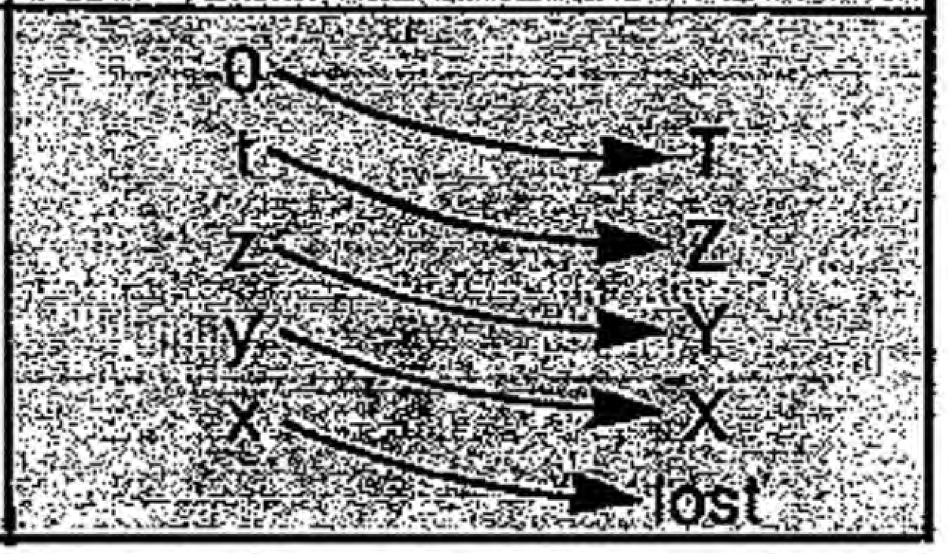
Appendix A — Stack Diagrams

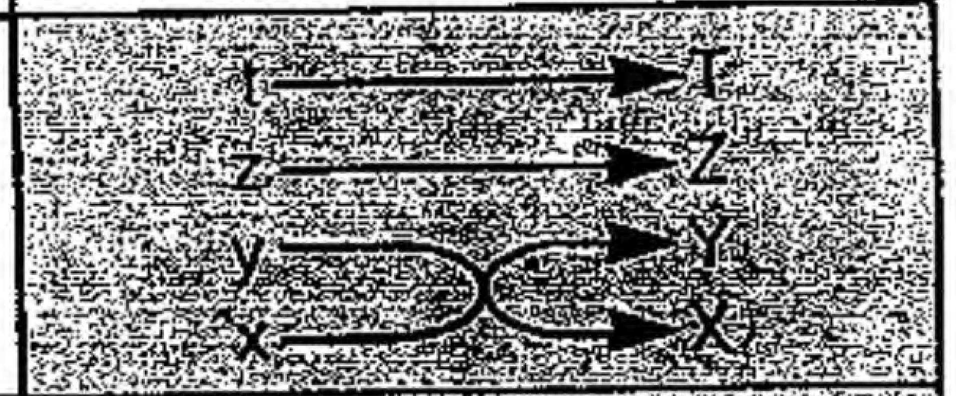
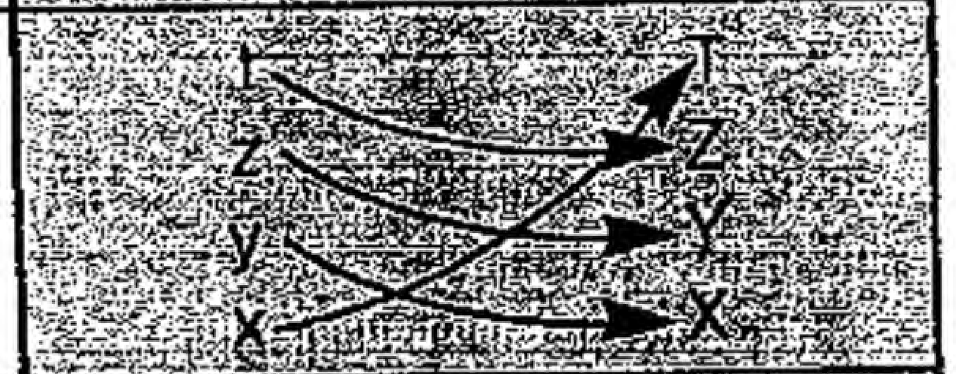
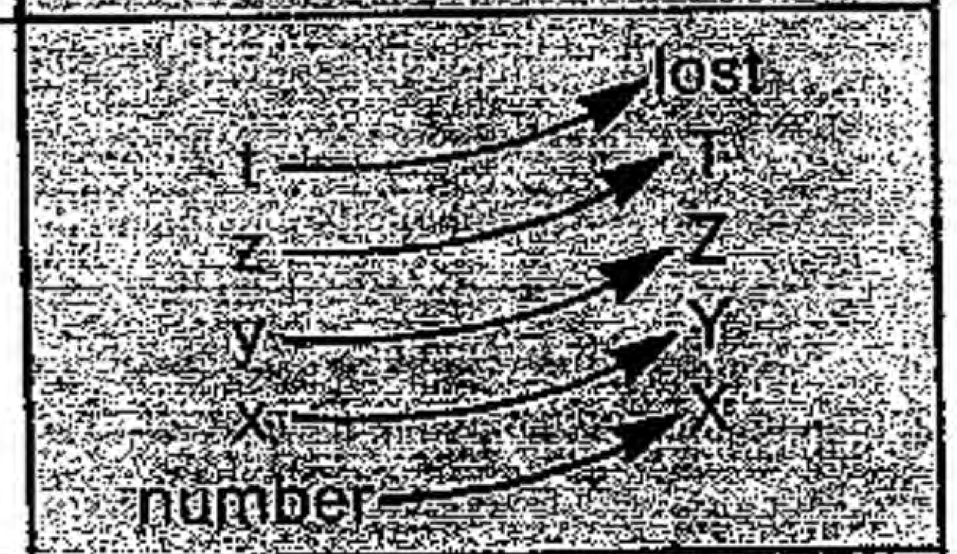
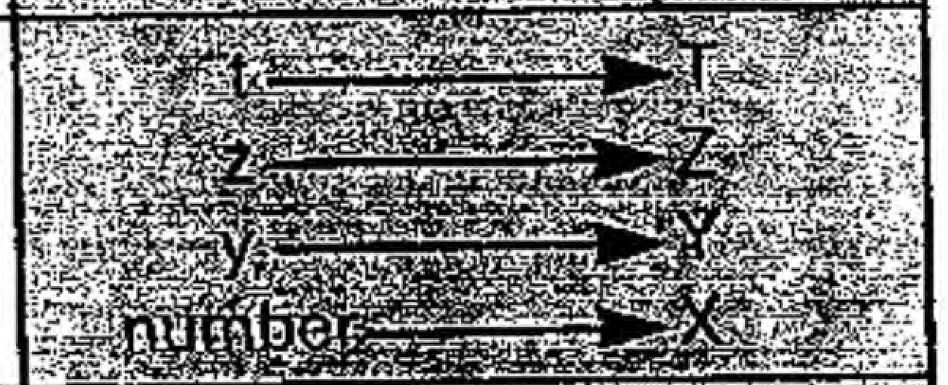
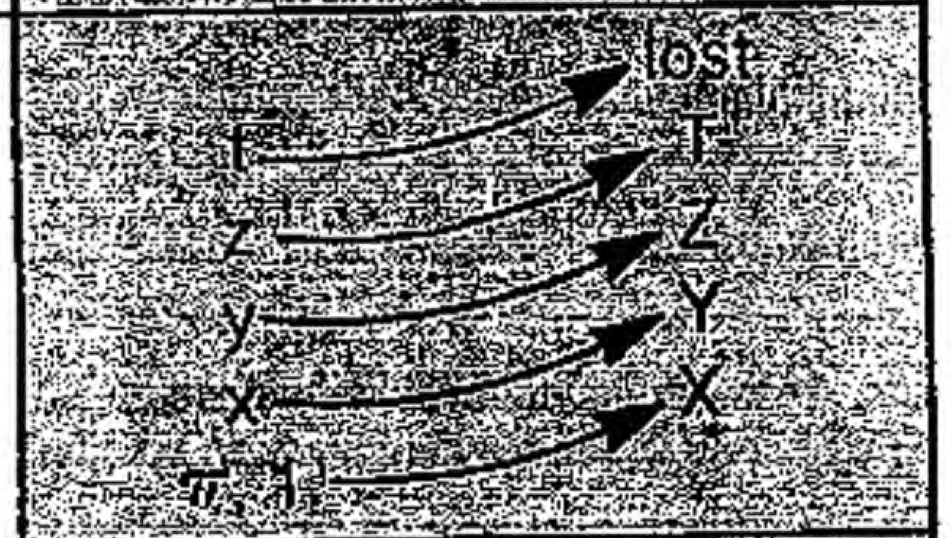
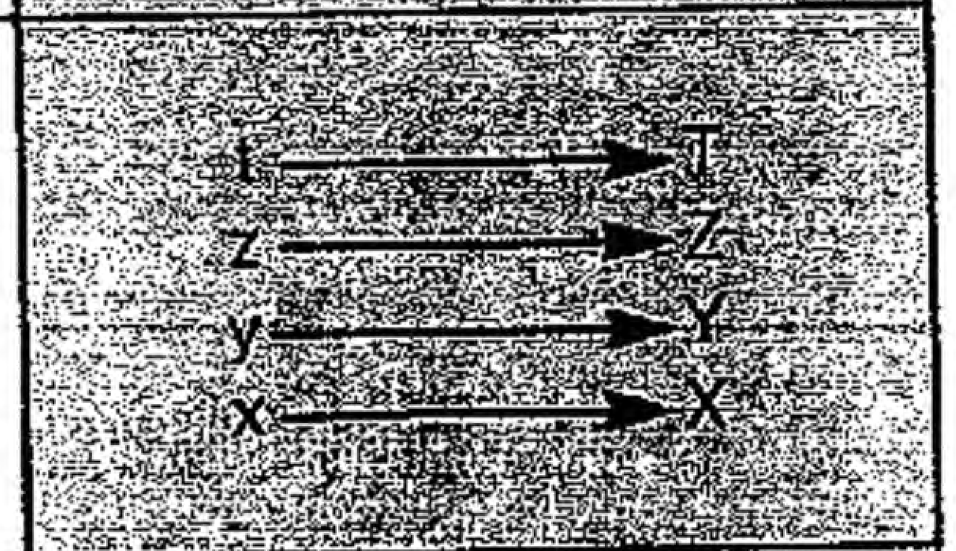
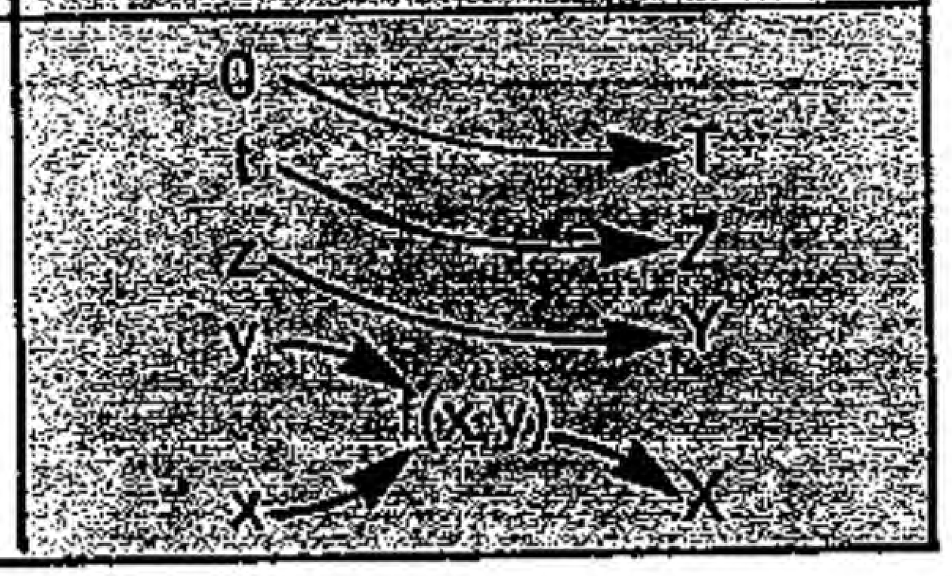
The following diagrams show what happens in the stack for each of the functions on your calculator. Remember that the contents of the registers (the numbers in the registers) are indicated by lower case letters x, y, z and t while the registers themselves are indicated by capital letters X, Y, Z and T. It is the contents of the registers, not the registers themselves, that move. For instance, the diagram for x↔y :



indicates that touching x↔y will move the contents (x) of register X to register Y and move the contents (y) of register Y to register X.

FUNCTION	STACK Contents	STACK Location	MEMORY Contents	MEMORY Location
Power-On or CA	0 →	T	0 →	M1
	0 →	Z	0 →	M2
	0 →	Y	0 →	M3
	0 →	X		

FUNCTION	CONTENTS LOCATION
EN	
C	

FUNCTION	CONTENTS LOCATION
x↔y	
ROLL	
First 0-9, • or 0-9, • after function key	
0-9, • after EN or after 0-9, •	
π or EEX after function key	
DS deg rad GRAD ENG F CF	
+ − × ÷ y^x	

FUNCTION	CONTENTS	LOCATION
→R →P Δ%	t → T z → Z y, x → f(x,y) → Y, X	T Z Y X
sin cos tan $\sin^{-1}$ $\cos^{-1}$ $\tan^{-1}$ DMS D ln e^x log 10^x	t → T z → Z y → Y f(x) → X	T Z Y X
1/x $\sqrt{\ }$ x^2 EEX X I x SD →KG →CM →LIT →LB →IN →GAL °F °C	t → T z → Z y → Y f(x) → X	T Z Y X

FUNCTION	STACK Contents	STACK Location	MEMORY Contents	MEMORY Location
Σ+ or Σ−	t → T z → Z y → Y x → X	T Z Y X	$m1 \pm x$ → M1 $m2 \pm x^2$ → M2 $m3 \pm 1$ → M3	M1 M2 M3

FUNCTION	CONTENTS	LOCATION
Sequence MR n n=1, 2 or 3	t → lost z → T y → Z x → Y m_n → X m_n → M_n	lost T Z Y X M_n
Sequence MS n n=1, 2 or 3	t → T z → Z y → Y x → X x → M_n m_n → lost	T Z Y X M_n lost
Sequence MS, +, −, × or ÷, n n=1, 2 or 3	t → T z → Z y → Y x → X m_n → lost $f(x,m_n)$ → M_n	T Z Y X M_n lost
M+	t → T z → Z y → Y x → X $x+m_1$ → M_1	T Z Y X M_1
Sequence MS x⇄y n n=1, 2 or 3	t → T z → Z y → Y x → M_n m_n → X	T Z Y X M_n

FUNCTION	CONTENTS	LOCATION
One-factor function ERROR	T Z Y X 0	T Z Y X lost
Two-factor function ERROR	T Z Y X 0	T Z Y X lost
Memory n function ERROR n=1, 2 or 3	T Z Y X 0 m_n	T Z Y X M_n lost

Appendix B — Hyperbolic and Inverse Hyperbolic Functions

The hyperbolic and inverse hyperbolic functions can be found by using the Gudermannian function:

$$\text{gd } x = 2 \text{ arc tan } e^x - \pi/2 \quad (\text{Note: } \pi/2 = 90°).$$

and the inverse Gudermannian function:

$$\text{gd}^{-1} x = \ln \tan [\pi/4 + x/2] \quad (\text{Note: } \pi/4 = 45°).$$

in conjunction with the following formulas:

$$\sinh x = \frac{e^x - e^x}{2},$$

$$\sinh^{-1} x = \ln [x + \sqrt{(x^2+1)}] = \text{gd}^{-1} (\sin^{-1} x),$$

$$\cosh x = \frac{e^x + e^x}{2},$$

$$\cosh^{-1} x = \text{sech}^{-1}\, 1/x,$$

$$\tanh x = \frac{\sinh x}{\cosh x} = \sin \text{gd } x,$$

$$\tanh^{-1} x = ½ \ln [1 + x/1 - x] = \text{gd}^{-1} (\sin^{-1} x),$$

$$\coth x = \frac{1}{\tanh x},$$

$$\coth^{-1} x = \tanh^{-1}\, 1/x,$$

$$\text{sech } x = \frac{1}{\cosh x},$$

$$\text{sech}^{-1} x = [\ln 1/x + \sqrt{1/x^2 - 1}\,] = \text{gd}^{-1} (\cos^{-1} x),$$

$$\text{csch } x = \frac{1}{\sinh x},$$

$$\text{csch}^{-1} x = \sinh^{-1}\, 1/x.$$

Examples:

Gudermannian function: gd 0.225.

Key in: . 225 F e^x F $\tan^{-1}$ 2 × 90 −

Display shows: 12.78413466.

Inverse Gudermannian function: gd^{-1} 60°.
Key in: F deg 60 EN 2 ÷ 45 + tan ln.
Display shows: 1.316957897.

Hyperbolic sine: sinh 2.5.
Key in: 2 • 5 F e^x EN 1/x − 2 ÷.
Display shows: 6.050204481

Hyperbolic cosine: cosh 2.5.
Key in: 2 • 5 F e^x EN 1/x + 2 ÷.
Display shows: 6.13228948.

Hyperbolic tangent: tanh 2.5.
Key in: 2 • 5 F e^x F tan^{-1} 2 × 90 − sin.
Display shows: .9866142982.

Hyperbolic cotangent: coth 2.5.
Key in: 2 • 5 F e^x F tan^{-1} 2 × 90 − sin 1/x.
Display shows: 1.01356731.

Hyperbolic secant: sech 2.5.
Key in: 2 • 5 F e^x EN 1/x + 2 ÷ 1/x.
Display shows: .1630712319.

Hyperbolic cosecant: csch 2.5.
Key in: 2 • 5 F e^x EN 1/x − 2 ÷ 1/x.
Display shows: .1652836699

Table 1: Results and operations resulting in an *Error* indication.

Results > 9.999999999 x 10^{99}.
Results < 1. x 10^{-99}.
Division by zero.
LOG, ln < 0.
SIN, COS, TAN > 25 revolutions (9000°).
TAN in multiples of ¼ revolution (90, 180° etc.).
SIN^{-1}, COS^{-1} > 1.
SIN^{-1}, COS^{-1} ≤ 10^{-50}.
$\sqrt{x} < 0$.
DMS/D conversions > 10^{10}.
x! not an integer, < 0 or > 69.

Table 2: Range accuracy and speed.

1. All trigonometric functions, logarithmic functions and y^x are accurate to 10 digits and are computed in less than 1 second.
2. 69! is accurate to 12 digits and is computed in 3 seconds.
3. All other functions are accurate to 12 digits and are computed in less than ⅓ second.
4. All functions work over the full mathematically allowable range as defined by the error conditions in Table 1.

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Consumer Products Division
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Kwun Tong,
Hong Kong.

Scotland
NS—UK Ltd.
National Semiconductor
Product Service
Larkfield Industrial Estate
Greenock PA 16 OEQ,
Scotland

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Product Service
D808 Furstenfeldbruck
Industriestrasse 10
Bundesrepublik
Deutschland

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Should your calculator need servicing, pack it carefully in a sturdy box for shipping. Proof of original purchase date must be enclosed. Be sure to include your name and return address. The package should be mailed postpaid to the nearest National Semiconductor Service Center. If your calculator is returned for warranty repairs more than ninety days after the original purchase date, you must enclose the appropriate service charge (if the service charge during the POST WARRANTY period has been changed, National Semiconductor will request you to supply the additional amount, if any is needed, or make the appropriate refund, if there is any difference, by check or money order payable to National Semiconductor).

NOVUS Warranty Certificate
Please retain for your records. See insert for trouble-shooting tips and product service locations.

Model Number____________________

Serial Number____________________

Purchased from____________________

Date purchased____________________

Please put your warranty into effect by completing this form and mailing it within 10 days from date of purchase to the NOVUS service center in your area.

Novus Model **4640**

Serial Number____________________

Purchase Date____________________
(month/day/year)

Purchased from____________________

Address____________________

City, State, Zip____________________

Your Name____________________

Your Address____________________

City, State, Zip____________________

Was this calculator purchased for:
- ☐ Gift ☐ Personal use

What is your occupation?
- ☐ Student or Teacher ☐ Professional
- ☐ Executive ☐ Financial or Commercial
- ☐ Engineering or Scientific ☐ Statistical fields
- ☐ Other occupation____________________

What is your age group?
- ☐ Under 18 ☐ 18-34 ☐ 35-49 ☐ 50-over

Where will you most use your Novus calculator?
- ☐ At home ☐ At school ☐ At work
- ☐ During travel

Where did you learn about the Novus calculators?
- ☐ Magazine ☐ Newspaper ☐ Television
- ☐ Radio ☐ Mail ☐ Store salesman
- ☐ Friend
- ☐ Other____________________________

What most attracted you to your Novus calculator?
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